Geographia Technica, Vol. 10, Issue 1, 2015, pp 28 to 43

GEOMATIC APPLICATIONS TOURBAN PARK IN PALERMO

Gino DARDANELLI[1], Silvia PALIAGA[1], Massimo ALLEGRA[1],Marco CARELLA[1], Valeria GIAMMARRESI [1]

ABSTRACT:
Over the last few years topographical techniques have developed an exponential trend towards simplifying and speeding, both survey operations and analysis of data collected reaching at the same time ever higher levels of accuracy. Among the technologies that are increasingly taking the field in this context is part of the Mobile Mapping System (MMS) that, on any mobile platform, combines sensors and measurement systems designed to provide a 3D position of the platform and, at the same time, capable to acquire geographic data without the aid of control points on the ground. The study reported concerns the verification of the reliability metrics and a qualitative MMS in order to evaluate its behavior in a particularly insidious as it can be an urban park; in particular, we report a series of experiments carried out from 2012 to the present in which we tried to test the potential of the system, comparing it with data from systems more "traditional", and to exploit all the products in an integrated survey carried out in dynamic mode.

Key-words: *Geomatics, MMS, Laser Scanner, GNSS, 360° camera.*

1. INTRODUCTION

The work proposed herein relates to the integration of a series of surveys conducted by the Department of Civil, Environmental and Materials Engineering of the *Polytechnic School* of the University of Palermo, as part of a campaign of studies begun in 2012 with the objective of investigating about the potential and the accuracy reached by MMS within the urban park *Ninni Cassarà* in Palermo.

The Urban Park Ninni Cassarà extends along a portion of land in Palermo, in the area south-east of the old town center. With a total area of over 28 hectares, spread from the archaeological site of the Pit Garofala, up to the present inner ring road of the city (the deviation of the riverbed Kemonia to the Oreto), it borders to the west with the street Altofonte and Corso Pisani and to east with the University of Palermo.

The old park, known as the "Garden of Orleans", was built around 1812 by Louis-Philippe Orleans. At that time, with an area of about 26 hectares, included a large citrus grove and an area devoted to the cultivation of vegetables, along with some ornamental and recreational adjacent to the villa and a more extensive used as a landscaped garden. Over time, because of the numerous changes of ownership, the entire area has undergone several transformations to its complete abandonment, although remained traces of ancient groves and avenues. Only between 1954 and 1957, the Sicilian Region has purchased the property entrusting the design and construction of the new park to the town planning officials of the Municipality of Palermo. Today the new park is for his visitors enjoyment of their free time in an environment populated by lush plants and developed, most of the time, in free form (**Fig. 1**).

The park is located at the edge of some neighborhoods and was dedicated by the City

[1]*University of Palermo, 90128 Palermo, Italy,gino.dardanelli@unipa.it; silvia.paliaga@unipa.it;massimo.allegra@gmail.com; marco_carella@hotmail.com; valeria.giammarresi@icloud.com.*

of Palermo to the memory of Vice Questor Ninni Cassara, Palermo cop murdered by organized crime August 6, 1985 and became a symbol of the struggle against the Mafia for its commitment.

The survey was planned in several phases: the first survey was played in the mode NRTK (Network Real Time Kinematic) on the site, which led to the creation of the plan of park and all infrastructure present. In second place were detected, mode EGNOS (European Geostationary Navigation Overlay System), the tree species in the park, these have been identified and cataloged and has been drawn up a plan of these tree species. The third phase of the investigation focused on the dynamic survey of the park with MMS which was followed by the laborious phase of return that led to the analysis of internal paths and the driveway of the park and the development of an application for maintenance management using spherical images.

2.METHODOLOGY BACKGROUND

In this paragraph are illustrated some of the most interesting experiences conducted in recent years both in urban parks as regards the survey methodologies used for our work, with the aim of providing the insights and references to those who, like us, decide to operate in this area.

The study of reference for the Mobile Mapping System is certainly that of Schwarz and El-Sheimy (1996), who first defined MMS:

"*A mobile mapping system that positions all visible objects of interest for an urban GIS with an RMS accuracy of 0.3 m while moving through a road corridor at a speed of 60 km/h and a maximum distance to the desired objects of 50 m. Data acquisition must be automatic and should contain real-time quality control features. Data processing, except for quality control, will be done in post mission and should have separate modules for georeferencing, image data base management, imaging, and quality assessment.*"

They developed over the years the technique of the tracking from a moving vehicle, in which data acquired from onboard sensors are directly georeferenced, or expressed in the desired reference system, thanks to a system of positioning and orientation installed on the vehicle itself and, as we will see below, to them we owe the algorithm (2004), still used for data processing MMS.

Figure 2 shows the Schwarz and El-Sheimytype of georeferencing, expressed by the **Equation 1**.

$$r_{IMU}^{m}(t) = r_{GPS}^{m}(t) - R_{IMU}^{m}(t) \cdot r_{IMU/GPS}^{IMU}$$ **Eq. 1**

Where: r_p^m is the position vector of point P in mapping frame and is unknown; $r_{IMU}^{m}(t)$ is the Origin position of the sensor in the mapping frame at time t and is obtained by processing GPS / INS; $R_{IMU}^{m}(t)$ is the rotation matrix from the IMU body frame to the mapping frame at time t and is obtained by processing GPS / INS; S_p is the ratio of the distance camera-point P and the vector length r_p^S and is return to stereo, laser scanner, etc; R_S^{IMU} is the rotation matrix between camera frame and body frame and is obtained from calibration gripping system; r_p^S is the vector of the image coordinates of the point P and is measured; $r_{IMU/S}^{IMU}$ is the position vector of the camera in the body frame and is obtained from calibration gripping system.

Fig. 1 Aerial photo of the park.

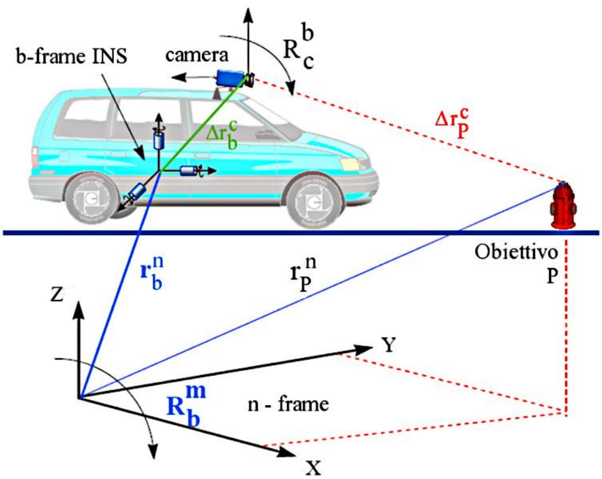

Fig. 2 Schwarz and El-Sheimygeoreferencing model.

The vector r_{IMU}^{m} (**Eq. 2**) is obtained by the antenna position, as a result of the ING/GPS data processing and taking account of the relative position vector between the GPS antenna and origin of the body frame.

$$r_{IMU}^{m}(t) = r_{GPS}^{m}(t) - R_{IMU}^{m}(t) \cdot r_{IMU/GPS}^{IMU} \quad \textbf{Eq. 2}$$

Where: $r_{IMU}^{m}(t)$ is the position vector of the GPS antenna phase center in the mapping frame and is measured; $r_{IMU/GPS}^{IMU}$ is the origin position of the sensor in the mapping frame and is obtained from calibration positioning system.

Among the most interesting part of the park is part of the study conducted by a team from the Center for Remote Sensing and Mapping Science (CRMS), Department of Geography, University of Georgia (USA). The authors describe the creation of a geocoded database of vegetation and undergrowth present in the Great Smoky MountainsNational Park, thanks to the integration of digital photogrammetry, photo interpretation and technique of GIS. They also used the GIS for the analysis of vegetation and the development of a model that allows to manage and control forest fires. Since the park in question is considered to be one of the wooded areas of the United States more difficult to map because of the height of the mountains and of the intense forest cover, the authors had planned to develop the techniques in question and then apply them to other areas of this type (Welch, Madden & Jordan, 2002).

Another important study is that conducted by the Centre of Excellence Telegeomatics of the *University of Trieste*, who, after having developed the MMS Gigione, has produced a prototype of the land registry of the roads to the Friuli Venezia Giulia, including all types of roads in the region (Manzoni et al., 2004).

Always in the field of the parks is interesting the work done by a group of researchers from the Graduate School of Agricultural and Life Sciences, *University of Tokyo*, Japan. The authors confirm the importance of the LIDAR technique, from aircraft or from the ground, for three-dimensional visualization of an urban park, and for the quantification of the different species of trees present in it. They come in particular to the development of the digital terrain model (DTM) and to the tops of the trees (DCHM) (Omasa et al., 2008).

Among the many interesting studies conducted with MMS technology is part one of a group of Finnish researchers through the FGI Roamer mobile mapping system developed at the *Finnish Geodetic Institute* has acquired road surfaces by studying the main features, the curbs and road markings present (Jaakkola et al., 2008).

Regarding the spherical photogrammetry, the Faculty of Engineering of the Polytechnic *University of Marche* conducted a very important experience. In particular, using the Topcon IP-S2, it was noted the People’s Palace and the Post Office building in Ancona and they have been acquired by the views effettuta return, using the algorithms of photogrammetry spherical previously processed (Fangi &Schiavoni, 2009).

Another interesting work is the one conducted by the Laboratory of Research in Biologic System and Geomatic Laboratory and the technic of water science from the *University of Mascara* in Algeria in collaboration with the Laboratory of Biodiversity and Conservation of Water and Soil, *University of Mostaganem*. The authors report the creation of a GIS such as multi-criteria decision support to preserve the biodiversity of the National Park of Ahaggar. This tool known as SDMA (Spatial Decision Making Aid) allows those involved in the management of the park to assess the relative priorities for biodiversity conservation in protected areas on the basis of a set of preferences, criteria and indicators developed for the area (Hamadouche et al., 2011).

An interesting application of the technology Laser Scanner is conducted by the laboratory GeCo (Geomatics for the Conservation of Cultural Heritage and Communication), *University of Florence*, in the context of the importance of historic gardens in Florence and in particular in the Park Pratolino was studied the interactions between the architectural elements present and the plant architecture of the park (Tucci, Conti & Fiorini, 2012; 2013).

The first results of the integrated survey of Ninni Cassarà Park in Palermo and the subsequent testing of methods, tools and techniques based on current research regarding the acquisition and processing of GNSS(Global Navigation Satellite System) data and NRTK (Network Real Time Kinematic) survey was reported in Dardanelli and Carella, 2013.

3. SURVEYING, DATA, TOOLS AND SOFTWARE USED

The first phase of the work involved surveying the park mode NRTK. In particular, we detected 16 vertices taken as control points, materialized through topographic spikes, and about 3800 points of detail necessary to identify the characteristic features of the park. Through a photographic survey (**Fig. 3**) of the whole area has been rated the best location for the vertices topographic taking account of presence of any obstructions or areas subject to multipath.

Fig. 3 Photographic survey of the park.

The survey campaign was planned based on a rough plan of the area; from the study of the morphology of the park has emerged the need to divide the surface into four zones, each of which encloses 4 control vertices so disposed to form a quadrilateral as regular as possible (**Fig. 4**).

Fig. 4 Plan of the park and the distribution of control points inside.

The first nail topographic (corresponding to the vertex V1), was placed in the path of the sidewalk adjacent to the park entrance on Via Ernesto Basile; the next 3 points of the "zone I", (V2, V3, V4), respectively, have been materialized in the portion of the park between the main entrance and the sport structure, named CUS (University Sport Centre) (outside the fence of the park). The 4 control points of the "zone II" are distributed near the theater (V5) within the car park (V8), and in the paths beside the artificial lake (V6 and V7). The points for the "zone III" are distributed so as to enclose the play area accessible from the Largo Claudio Traina, the former Corso Pisani (V9, V10, V11, V12). The control points of the IV enclose the entire complex of the rink, including the "serpentine" that leads to the last picnic area north-east of the park (V13, V14, V15, V16).

Fig. 5NRTK survey.

The measurements were carried out without assess in advance the quality of the geometric satellites configuration. The study has provided six days of measurements (**Fig. 5**), from 9.00 to 17.00, effective time of the instruments battery cycle. For the survey of the 16 control vertices was chosen an acquisition time of 60 seconds, and arming the rod geodesic with appropriate bipod. The receiver has acquired the real-time corrections from the network of permanent stations of the *University of Palermo* via NTRIP protocol (Dardanelli, Franco & Lo Brutto, 2009). The acquisition time fixed for the relief of the points of detail has been instead of 1 second; it was not necessary to use the bipod and therefore the correct geodetic vertical rod has been entrusted exclusively to the spherical level to which it is provided. The survey was carried out by the receiver Leica GS-15 Controller with *Leica CS-10*.

The data acquired by the instrument during the sessions were downloaded directly from the memory card housed in the receiver controller on the PC and viewed with *Leica Geo Office 8.4* software.

Fig. 6 Survey of tree species.

The second phase of the work consisted in the mode EGNOS survey, which covered the tree species found within the park, as for the relief NRTK, were initially materialized 16 control points that were detected by GPS in static mode, then detect over 4100 entities in the park (**Fig. 6**).

The survey of the individual entities was performed with sampling intervals of about 5 seconds. In the initialization phase has been fixed instrumental height of 1.20 m, which is assumed constant for the duration of the reliefs.

The measurements were made through the use of a PDA *GeoXH Trimble*, can provide an accuracy of the order of decimeter thanks optional Zephyr external antenna, thus eliminating the need for data processing in back office. The acquired data were then inspected using the software of Trimble GPS *Pathfinder Office 4.0*.

The third phase of the work has focused on the importance of the park in MMS mode *Ninni Cassarà* and the section of the street Ernesto Basile that allows access to the park. The survey was carried out via the IP-S2 Mobile Mapping System of Topcon.

The essential components of a MMS, as is known in literature, are: the acquisition sensors, the positioning system, the synchronization and georeferencing system, the storage system of the acquired data. The acquisition system is constituted, in most cases, from laser scanners, and spherical cameras.

The system of positioning and orientation GNSS-INS (Inertial Navigation System) is composed by the GNSS receiver, inertial measuring from IMU and odometer. The GNSS receiver establishes a geospatial position of the points surveyed stating the coordinates in WGS84, time by time. The inertial meter is able to determine the vehicle trim, compared to the global reference system providing the angles of roll and pitch and heeling. The odometer provides information about the distance covered and the acceleration of the vehicle. Together with data from IMU guarantees absolute positioning in case of loss of GPS signal.

The IP-S2 is a modular system that can be configured with multiple sensors; the system used in this study (Fig. 7) is the standard, consisting of three Lidar scanner with high resolution, properly arranged to cover the road surface and the adjacent buildings up to a distance of 30 m and a digital camera at high resolution to provide 360° spherical images at a rate of 15 frames per second; a dual-frequency GNSS receiver establishes that the geospatial position; an inertial platform IMU, which provides the structure of the vehicle; a connection to the external encoders on the wheels to acquire odometry information; a PC with IP-S2 software on board for the management of data through this the user will monitor and verify the operating status of all devices connected to the control unit (IP-S2 box), which acts as the synchronization of all sensors connected to it: the GNSS receiver, IMU, odometer, laser scanner and digital camera 360°.

The survey was designed to detect both the entire park that the driveway. The vehicle left the University, after has walked away from Ernesto Basile then advancing inside the park, by detecting entirely and providing the data on the positioning GNSS- INS, since the laser and the spherical images of the area (**Fig. 8**).

The data obtained were visualized using the *Spatial Factory* software from Topcon. The software provided the trajectory covered by the vehicle, the point cloud captured by the laser scanner during the survey campaign and the spherical images of the 360 ° camera. The three types of data obtained have been developed individually in order to evaluate the potential of the instrument and the accuracy attainable.

Fig. 7 The Topcon IP-S2.

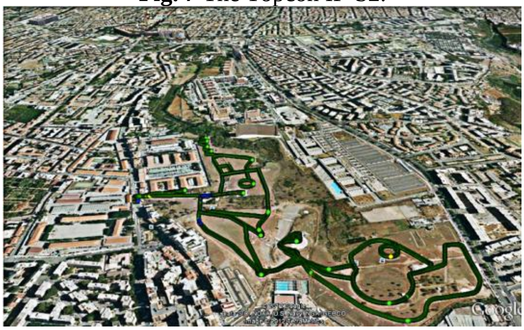

Fig. 8 Trajectory followed by 'IP-S2.

4. DATA PROCESSING

Regarding the NRTK survey, using the software *Leica Geo Office* has been possible to visualize the complete overview of the 3786 surveyed points (both fixed that float). For each point, the software has provided the class of the point (or phase code), the date and time of the acquisition, the coordinates WGS84 geocentric and the quality of the data; this also has allowed to visualize the detected points and highlight the baselines that connect the master to the rover (**Fig. 9**); in our case the role of rovers has been performed by the permanent station of the *University of Palermo*.

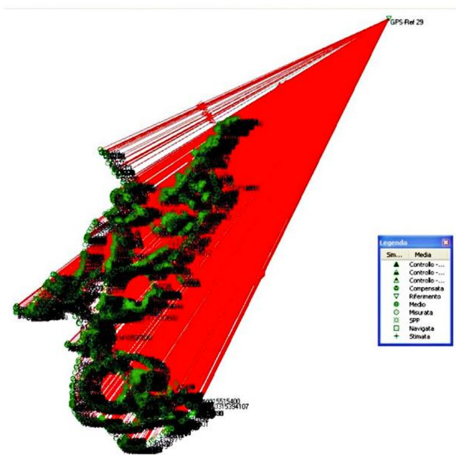

Fig. 9 Points cloud and relative baselines.

Having worked in NRTK mode has not been operated any post-processing of the data, was only checked the level of precision achieved and was considered acceptable. The points that have presented high difference have been removed, but for the most part it was those whose phase ambiguity has not been fixed (float).

For the type of processing required, the field book in .pdf that is returned by *Leica Geo Office* was not customizable; the need to include a significant amount of points on *Autocad* and that to have a custom table of all parameters of interest that the software allows to obtain, has led to the need to work with reports in simple text format. In this regard, 5 templates have been created to report: WGS84 geographic coordinates, standard deviation, as in three dimensions, number of satellites and DOP indexes; that made possible the processing of the results obtained.

Finally, in order to classify the importance in the digital mapping of the city of Palermo, it was necessary to transform WGS84 coordinates in Italian Datum *Gauss-Boaga* Rome 40 plane coordinates; the transformation was performed using the software *Verto 3K* by IGMI (Italian Geographic Military Institute).

As regards the EGNOS mode survey data acquired were processed using the commercial software of Trimble *GPS Pathfinder Office 4.0*, which has allowed us to visualize these points (**Fig. 10**).

The raw data were corrected mode EGNOS based, therefore, on all the stations on the European Geostationary Navigation System, in support of the global GPS system. The software used provided the precision and the coordinates of each point observed.

As regards the relief MMS the three types of data collected by the integrated system, GNSS-IMU positioning, since spherical panoramas and laser have been developed in three distinct phases.

For positioning satellite instead we have conducted a study on the accuracy achieved. As known, one of the elements that most influence the measurement precision GPS is the configuration of the satellites and their visibility.

The DOP (Dilution Of Precision), as known in the literature, can be defined as a measure of the degradation of the accuracy of positioning linked to the geometry of the satellites, it is defined by the parameters: PDOP (Position Dilution Of Precision), HDOP (Horizontal Dilution Of Precision), VDOP (Vertical Dilution Of Precision).

During the survey were approximately 10 GPS satellites and 8 GLONASS for a total of 18 satellites for the duration of the relief. Because the survey was carried out in a city park characterized by full satellite coverage and a traffic flow zero, these conditions have allowed for a objective feedback on the accuracy and quality of the data.

The complete absence of obstacles and obstruction in the test area has also allowed returning the entire kinematic chain with a single static initialization, causing the components in the WGS84 reference system.

Considering the data acquired by the laser scanner, installed on the IP-S2, the resulting point cloud was divided so as to be able to process separately the data within the park and the data for Ernesto Basile street, where there is access to the park.

Regarding the interior of the park, the cloud was still significantly heavy, as composed of about 12,000,000 points, for which, for easier management, has been divided into four parts (**Fig. 11**) using the software *Text Magician*.

Fig. 10: Distribution of surveyed points in EGNOS mode.

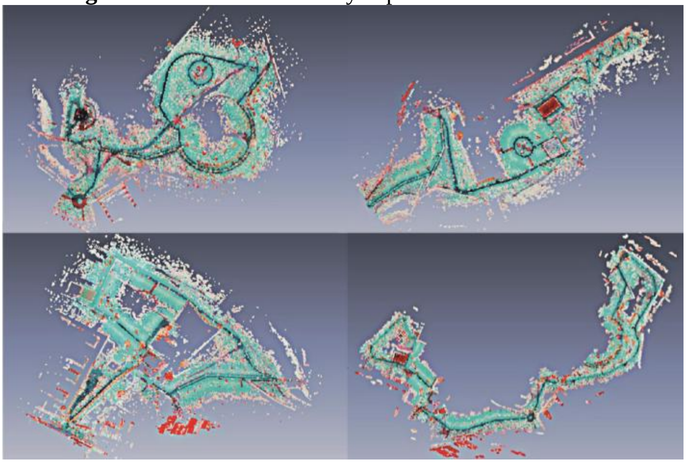

Fig. 11 The four parts.

The four files obtained in txt format, were managed with software *Rapidform XOR*, in particular, after conducting processing operations base, such as noise filtering, sampling and smooth, it was decided to focus the study on a particular stretch the pedestrian path that presents a variation of slope and curvature along its development. The trait under study was identified in the fourth fraction of the point cloud, and this was isolated (**Fig. 12**).

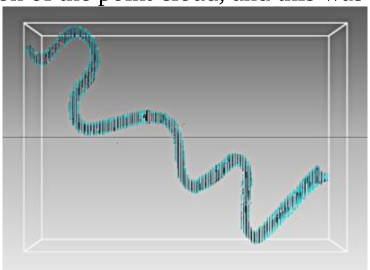

Fig. 12 Isolated stretch.

In order to analyze the quality of the data acquired with the scan and in particular the level of detail of the points provided by the survey, this stretch have been studied specific cross sections, it also has been traced longitudinal profile. For the study of the whole portion of the route considered have been traced fourteen sections, were exported in ASCII format and then imported into the *Rhinoceros* software to proceed with the processing and analysis of them and come to the reconstruction of the trajectory of the path, to the realization of the longitudinal profile, and the analysis of the section of roadway in various points of the same.

In order to identify a typical section useful for the creation of a digital 3D model of the entire route, it was considered a part of the extension of approximately 15 m, by that were extracted six sections. Each of the sections was analyzed individually and is being tracked, in a manner as precise as possible, the lie of the land, effecting a direct point to point construction. Finally, these reconstruction were imported into the software *Autocad* and overlapped with each other for the detection of average lie of the land .

Subsequently, it has been suggested the type section that the path analyzed should present while considering that the land in question is partially anthropized, and therefore subject to change over time. The type section has been developed along the middle path, achieving the idealized three-dimensional model of stretch studied (**Fig. 13**).

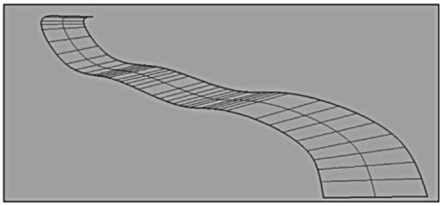

Fig. 13 Idealized three-dimensional model of stretch studied.

The generated 3D model has been superimposed with the corresponding point cloud in order to analyze the accuracy of the data acquired from the laser scanner during the survey; in order to make the overlap between the two entities was necessary to triangulate the point cloud. It is obtained then the deviation of the model created by the points of the cloud (**Fig. 14**) and varying the resolution and the value of the maximum range of comparison between the two entities was carried out of the goodness metrics and qualitative analysis of the instrumentation used and the reconstruction performed.

The spherical image obtained with the IP-S2 have been used for the execution of an application to support the activities of maintenance and management of elements of the park subject to periodic degradation. In particular, we wanted to create a tool that allows the maintenance operator to compare, constantly and in every place, the state of affairs of a park with the optimal one, and to detect irregularities.

Through *Spatial Factory* software has been exported, first, the trajectory followed by the vehicle in KML format and secondarily geographical coordinates, relative to all the spherical images (**Fig. 15**), in the reference system WGS84.

For each individual image has been constructed a coordinate system using the software *3DS Max* from *Autodesk* that has allowed to realize a sphere, having a radius equal to the focal length of 14 mm camera of the outlet, on which overlay the image.

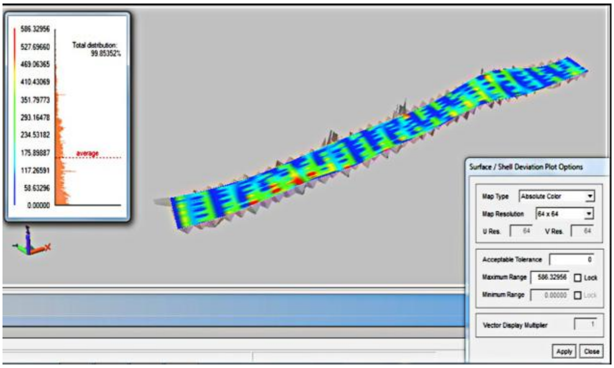

Fig. 14 Overlap of the model to the cloud.

Fig. 15 spherical images 360 °.

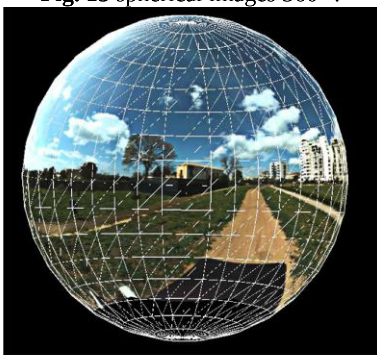

Fig. 16 Overlapping Spherical panorama on the sphere.

It is then imposed a system of reference having its origin in the center of the sphere, which has allowed us to make the “Mapping” (**Fig.16**), which is to transform the image coordinates (u, v) in 2 dimensions in the frame, in the coordinate x, y, z belonging to the sphere. This has allowed us to be able to locate each element on the image through a pair of coordinates in three dimensions. Furthermore, knowing the center of taking picture, in WGS84 coordinates, detected at the time of the relief, it was possible to carry out a rototranslation in space, from a local coordinate system x, y, z to a global coordinate system, λ, φ, h (latitude, longitude and altitude).

Once determined the zero point, the application has been designed with the aim to ease the task of collecting and managing the maintenance of an urban park.

The interface design was based on the principles of interaction design, examining how and what the service technician need both to improve the efficiency and effectiveness of its inspection, and what is necessary at the technical control center to monitor the costs for maintenance, inventories and effectiveness of all maintenance carried out.

5. RESULTS

The relief NRTK of the park has produced a geo-referenced point cloud, then this was superimposed on the CTR (Regional Technical Map) in digital format and found that this overlap presented acceptable deviations. This operation gave confirmation of the result of the work carried out in the countryside. The work led to the drafting of the plan of the park and the whole street furniture associated with it.

The relief EGNOS produced the Plan of tree species of the park by using the Trimble *Pathfinder Office Software Geo*. The plan it was accompanied by legends, which are associated with the individual symbols on the names of the tree species and other information about the structures inside the park; was finally overlapped on the relief NRTK in order to assess the accuracy achieved. The two plans overlap with good precision.

Regarding the satellite positioning performed by MMS, for the duration of the relief the DOP values are kept very low a sign of a good satellite visibility, especially a good precision of the relief. In fact, the HDOP is always kept below the value 1, as well as the PDOP and the VDOP are always kept below the value 2. Analyzing the results obtained with the laser survey of the interior of the park, after completing its digital model, it was possible to change both the resolution and the limits of maximum tolerance between the position of the points of the survey and the points of the 3D model. Initially, to the digital model created has been assigned a maximum value of the tolerance of 2m, as provided by law, and without changing this tolerance the model has been designed with a low resolution (64x64 pixels) and a resolution upper (1024x1024 pixels). As noted, the path object of study which is in a city park does not have a true road infrastructure; in this case it was beaten ground and, since there is no standard of reference, it was decided to impose a different value to the maximum tolerance provided, between the position of the points of the pad and that of the points of the ideal model. The maximum range was, therefore, set equal to 3 m and were made, also in this case, the digital models to low resolution (64x64 pixels) and high resolution (1024x1024 pixels).

In the case of low resolution the value of the average distance between the ideal model and the point cloud was equal to 1.59 m and the value of the standard deviation of 1.24 m. The total distribution of the points raised with respect to the ideal model was found to be 86%. In this case, having increased the maximum range of the tolerance, you can see how the model is to be approximated in the best way the point cloud generated by the relief. Specifically, compared to the case in which it was taken as the maximum tolerance of 2 meters, the adaptability of the ideal performance of the surveyed points is increased by about 20%. (**Fig. 17-18**).

As for the survey using laser technology to street Ernesto Basile, the idealized three-dimensional model has been superimposed on the point cloud acquired and analyzed the distances from one another and thus the accuracy of the data acquired by the laser scanner at the time of the survey.

Since the objective of this study was to evaluate the applicability of the MMS technology to the relief of road sections aimed at the Land Registry and roads as the maximum tolerance allowed by the *Land Registry Italian* roads to the extent of the length of roadway is 10 cm, the cloud of points was superimposed on the ideal model, using the software *Geomagic*, which allowed to obtain the deviations between the two models, which are also found to be acceptable by imposing a tolerance of 0.1 m.

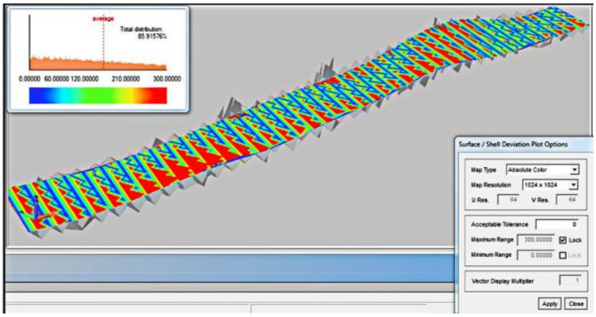

Fig. 17 Digital model of low resolution with maximum tolerance of 3 m.

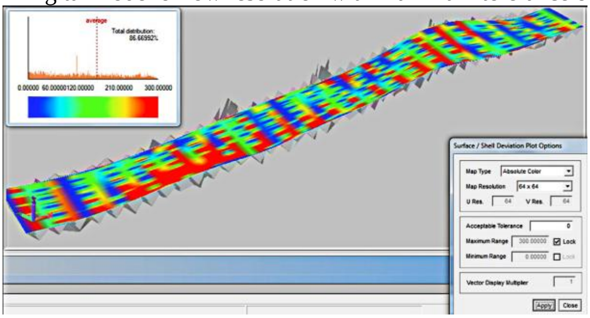

Fig. 18 Digital model of high resolution with maximum tolerance of 3 m.

After completion of the processing, the results obtained were compared with those for the relief of the paths in the park *Ninni Cassara*. In that case, the operating conditions were different and the level of detail achieved in the measurements was less than that obtained in street Ernesto Basile, in fact, as expected, the instrument has suffered the irregularity of the unpaved roads and the lack of homogeneity of the material detected over that of the degree of reflectivity, definitely lower than that of the bituminous conglomerate of the urban section described here.

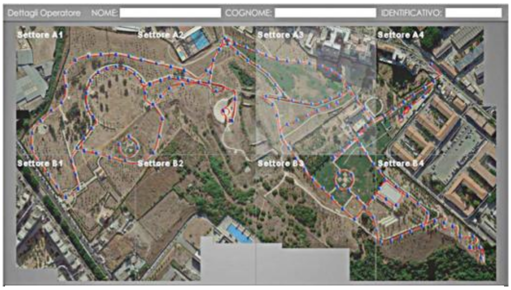

Fig. 19 Orthophoto of the park classified into sectors.

Fig. 20 Maintenance board.

Regarding the development of the application for the maintenance of the park, the software has been designed according to subsequent three tabs; the first contains the name and logos of the companies that you are interested in the development of the application and the start button that lets you start the program.

The second tab is composed of three panels that allow to enter the credentials of the operator and an orthophoto of the whole park divided into sectors (**Fig. 19**), which if clicked allows you to view the third tab with all spherical images related to the selected sector.

The operator responsible for the maintenance of interest by clicking on the image opens it and knows the geographic coordinates of the selected image, also by comparing the state of the park at the time of the survey with the optimal one can highlight on the spherical panorama irregularities detected for the various categories elements that characterize the park (roads, signage, lighting, irrigation, buildings, trees and shrubs, turf) by clicking one of the buttons activates a marker that allows you to focus on the spherical panorama factor which must be subjected to maintenance (**Fig. 20**).

6. CONCLUSIONS

This complex work here shown has brought to the results that were previewed during the projecting phase of the whole survey. The final results are: the realization of the park *Ninni Cassarà* plan, make by the NRTK survey mode; the realization of the tree species plan and their cataloging obtained by EGNOS positioning; with the study of the MMS system potentiality and level of accuracy, both in terms of the delivery system, that means the GPS data, as regards both the acquisition sensors. In particular it highlighted the extraordinary immediacy of laser survey form MMS and the great level of detail achievable, although the level of accuracy reached with the internal patch survey was lower than that one reached with the access road, because, as was to be expected, in the first case the instrument suffered the irregularities of the unsurfaced paths, in addition to the degree of reflectivity, certainly lower than that of bitumen of the urban road. In addition these work allow to creating an application to support the maintenance and management of the park, that can help both who have to scheduled it as who should do it, on making all the operations and the communication more quick.

Nowadays the *Ninni Cassarà* Park is close to the public, because of the discovery of the presence of asbestos; all the people are waiting an intervention of reclamation that can return this oasis to the people.

REFERENCES

Dardanelli, G., Franco, V. & Lo Brutto, M. (2009) Accuracy and reliability in GNSS NRTK.In: *Proceedings of European Navigation Conference - Global Navigation Satellite Systems*,Naples, Italy.

Dardanelli, G. &Carella, M. (2013) Integrated Surveying with Mobile Mapping System, EGNOS, NTRK and laser technologies in the park “Ninni Cassara” in Palermo.*ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, Volume II-2/W1, ISPRS 8th 3DGeoInfo Conference & WG II/2 Workshop.

Fangi, G. & Schiavoni, A. (2009) Una esperienza di Mobile Mapping con la fotogrammetria sferica. *Proocedings of 13° Italian National Conference ASITA*.

Hamadouche, M. A., Mederbal, K., Khaldi, A., Kouri, L., Driss, M., Fekir, Y., Anteur, D. & Oulha R. (2011) Geomatic tools and multi-criteria analysis for managing and conserving the biodiversity of the National Park of Ahaggar (Algeria).*Arabian Journal of Geosciences*, 7, 2, 419-434.

Jaakkola, A., Hyyppä, J., Hyyppä, H. & Kukko, A. (2008) Retrieval Algorithms for Road Surface Modelling Using Laser- Based Mobile Mapping.*Sensors*, 8, 5238-5249.

Manzoni, G., Bolzon, G., Martinolli, S., Pagurut, R., Rizzo, R. G. & Sluga, T. (2004) Ultimi risultati del rilevamento di strade con MMS e sue applicazioni interdisciplinari.*Proocedings of National Italian SIFET Conference ASITA.*

Omasa, K., Hosoi, F., Uenishi, T. M., Shimizu, Y. & Akiyama, Y. (2008) Three-Dimensional Modeling of an Urban Park and Trees by Combined Airborne and Portable On-Ground Scanning LIDAR Remote Sensing. *Environ Model Assess,* 13, 473–481.

Schwarz, K.P. & El-Sheimy, N. (1996) Kinematic Multi- sensor Systems For Close Range Digital Mapping. *ISPRS*, 1996, Commission V, Working Group III, Vienna, Austria.

Tucci G., Conti A. & Fiorini L. (2012) Geomatics for Knowledge and Conservation of Cultural Heritage: The Pratolino Park Case-Study. P*roceedings of the 1st International Congress ICONARCH*, “Architecture and Technology”, pp. 428-440.

Tucci, G., Conti, A. & Fiorini L. (2013) Scansione laser per il rilievo dei giardini storici. *GEOMEDIA*, 17, 14-18, ISSN:1128-8132.

Welch, R., Madden, M.& Jordan, T. (2002) Photogrammetric and GIS techniques for the development of vegetation databases of mountainous areas: Great Smoky Mountains National Park. *ISPRS Journal of Photogrammetry & Remote Sensing*, 57, 53–68.